§7. Motion of the Plasmoid in Helical Plasmas

Ishizaki, R., Nakajima, N.

It is well known that an ablation cloud; a high density and low temperature plasmoid, drifts to the lower field side in tokamak plasmas, which leads to a good performance on fueling in tokamak. Such a good performance, however, has not been obtained yet in the planar axis heliotron; Large Helical Device (LHD) experiments, even if a pellet has been injected from the high field side. The purpose of the study is to clarify the difference on the plasmoid motion between tokamak and LHD plasmas by using the MHD simulation including ablation processes [1].

It is found in tokamaks that the drift motion is induced by a tire tube force and 1/R force {in the major radius direction}, and that the pressure and density of the plasmoid have oscillation due to fast compressional Alfven wave. It is also found that the plasmoid dose not drift when the perturbation of the plasmoid is small. The first trial simulations on the motion of the plasmoid in LHD plasmas also show that the plasmoid drifts to the lower field side similarly to tokamaks. In addition, the motion of the plasmoid is investigated in straight helical plasmas in the cases that the plasmoids are located at lower and higher field sides than one at the magnetic axis. The rotational helical coordinate system (u^1, u^2, u^3) is used in which the poloidal cross section (u^1-u^2 plane) rotates along the straight toroidal direction (u^3) with same pitch as the external helical coils [2]. Figures 1(a) and (b) show the poloidal cross section (u^1-u^2 plane) at $u^3 = 0$ and the flux surface (u^3-θ plane) through the center of an initial plasmoid, respectively, where θ is the poloidal angle defined by $\theta = \mathrm{Tan}^{-1}(u^2/u^1)$. The plasmoid encounters the electrons with fixed temperature 2 keV and density 10^{20} m^{-3}. Figures 1 (c) and (d) show the contours of the mass flow through the flux surface in which the initial plasmoid is located. A negative flow means one toward the magnetic axis. When the plasmoid is heated, the pressure of it increases. It is found in Figs. 1 (c) and (d) that the plasmoid quickly expands along the magnetic field and simultaneously drifts to the outside, namely the lower field side. The fact is due to a tire tube force and a 1/R force induced by the magnetic field with curvature similarly to the tokamak. The case that the plasmoid is located at the highest field side on the flux surface is considered. Figures 2 (a) and (b) show the poloidal cross section at u^3=0 and the flux surface through the center of an initial plasmoid, respectively. The conditions except the initial location of the plasmoid are same as Fig. 2. Figures 2(c) and (d) show the contour of the mass flow on the flux surface. It is found that the plasmoid quickly expands along the magnetic field and simultaneously drifts to the inside, namely the lower field side as shown in Fig. 2(c). Subsequently, the mass flow at θ = 0 becomes positive as shown in Fig. 2 (d), namely the plasmoid drifts to the outside. In other words, it drifts to the higher field side. This fact might be one of the reasons why the motion of the plasmoid dose not depend on the location of the pellet injection so much in LHD experiments. Such a difference between tokamak and helical plasmoid will be clarified, and the motion of the plasmoid will be evaluated in LHD.

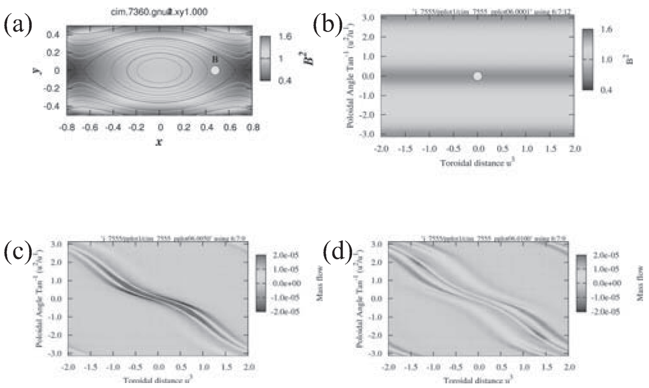

Fig. 1. Initial location of the plasmoid at lower field side in (a) the poloidal cross section and (b) the flux surface. Contours of the mass flow at (c) t=5.0 and (d) 10.0 τ_A, through the flux surface.

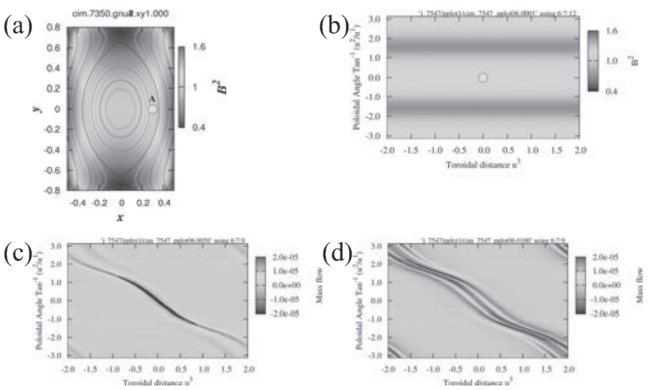

Fig. 2. Initial location of the plasmoid at higher field side in (a) the poloidal cross section and (b) the flux surface. Contours of the mass flow at (c) t=5.0 and (d) 10.0 τ_A, through the flux surface.

1) Ishizaki, R. et al.: Phys. Plasmas **11** (2004) 4064.
2) Harafuji, K. et al.: J. Comp. Phys. **81** (1989) 169.